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Technical work: consideration of draft risk profiles: Dechlorane Plus and its syn-isomer and anti-isomer

Additional information on the draft risk profile for Dechlorane Plus and its syn-isomer and anti-isomer

Note by the Secretariat

As is mentioned in the note by the Secretariat on draft risk profile: Dechlorane Plus and its syn-isomer and anti-isomer (UNEP/POPS/POPRC.16/2), the annex to the present note sets out additional information on the draft risk profile for Dechlorane Plus and its syn-isomer and anti-isomer prepared by the intersessional working group on Dechlorane Plus and its syn-isomer and anti-isomer. The present note, including its annex, has not been formally edited.

* Reissued for technical reasons on 19 October 2020.

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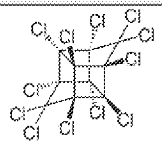
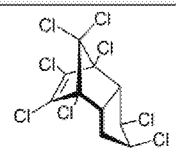
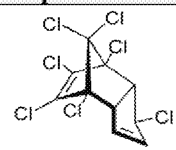
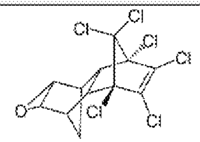
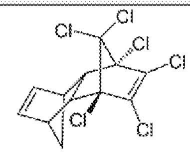
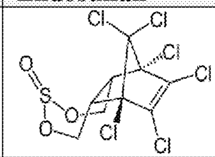
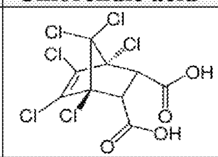
Annex

Additional information on the draft risk profile on Dechlorane Plus and its syn-isomer and anti-isomer

Table 1. Physico-chemical properties of chemical analogue substances listed in Stockholm Convention. Information adopted from ECHA, 2017d

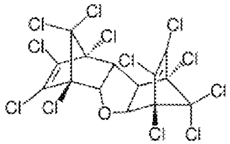
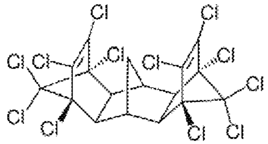
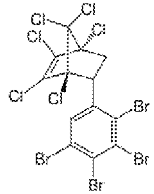
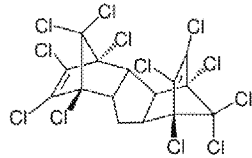
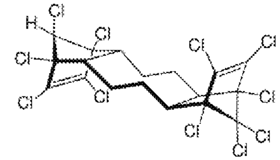
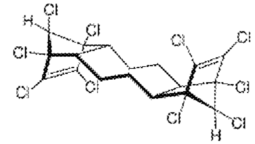
Substance name	Mirex	Chlordane[a]	Heptachlor[b]	Dieldrin[c]	Aldrin[d]	Endosulfan[e]	Chlorendic acid*
Structure							
CAS No.	115-85-5	57-74-9	76-44-8	60-57-1	309-00-2	115-29-7	115-28-6
MW, g/mol		409.78	373.32	380.91	364.90	406.93	388.85
Water solubility, 25°C		0.056 mg/L	0.18 mg/L	0.195–0.25 mg/L	0.05 mg/L[f]	0.017 mg/L	3,500 mg/L measured 1.5 mg/L estimated
Log K_{ow}		6.1–6.2	5.5–6.1	5.2–5.4	6.5– 6.8	6.5	

* Not listed in the Stockholm Convention

Substances are mixtures or have several different isomeric forms:
a – Chlordane consists of more than 140 compounds, of which *trans*-chlordane, *cis*-chlordane and *trans*-nonachlor are present in the highest amounts (Dearth & Hites, 1991; Liu et al., 2009).
b – Technical heptachlor usually contains about 72 % (±)-heptachlor and 28 % related compounds including about 18 % trans-chlordane (EFSA, 2007).
c – A stereoisomer of dieldrin called endrin (CAS No. 72-20-8) was also made commercially. It has effectively similar physico-chemical properties as dieldrin.
d – A stereoisomer of aldrin called isodrin (CAS No. 465-73-6) was also made commercially. It has effectively similar physico-chemical properties as aldrin.
e – Technical endosulfan consists of three stereoisomers.
f – Value from GESTIS Substance Database. Available from: [HYPERLINK "http://gestis-en.itrust.de/nxt/gateway.dll?f=id$t=default.htm$vid=gestiseng:sdbeng$id=510027"]

Chemical structures were drawn, using stereochemical information from [HYPERLINK "https://well-labs.com/docs/efrs_20dec2012_wr.pdf"].
Note: Enantiomers have identical physico-chemical properties. However, this is not the case for diastereomers such as endo-exo isomers. Most QSAR software including EPI Suite do not make a difference,
whereas e.g. COSMOtherm does.

Table 2. Physico-chemical properties of dechlorane-related substances and de-chlorinated Dechlorane Plus (information adopted from ECHA, 2017d)

Substance name	Dechlorane 602	Dechlorane 603	Dechlorane 604	Chlordene Plus	DP-C_{11}	DP-C_{10}
Structure						
CAS No.	31107-44-5	1360-92-4	3471-16-9	13560-91-3	-	-
MW, g/mol	613.62	637.68	692.51	611.62	619.29	584.84
Water solubility, 25°C	<1.7E-06 mg/L	<6.4E-07 mg/L	<4.7E-06 mg/L	<6E-07 mg/L		
Log K_{ow}	8.0	11.2	10.6	9.8		

All the substances have several different isomeric forms.
Chemical structures were drawn, using stereochemical information from [HYPERLINK "https://well-labs.com/docs/efrs_20dec2012_wr.pdf"].
Note: Enantiomers have identical physico-chemical properties. However, this is not the case for diastereomers such as endo-exo isomers. Most QSAR software including EPI Suite do not make a difference, whereas e.g. COSMOtherm does.

Table 3. National regulatory processes for Dechlorane Plus and its isomers

Country/ organisation	Regulatory process
Canada	DP is listed on Canada's Domestic Substances List (DSL) (ECCC, 2019). A final screening assessment of DP was published by Environment and Climate Change Canada (ECCC) and Health Canada in spring 2019 (Canada, 2019a). The assessment concludes that DP meets the criteria for toxicity to the environment, as it is entering or may enter the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity. The proposed regulatory approach is to amend the *Prohibition of Certain Toxic Substances Regulations, 2012* to prohibit the manufacture, import, use, sale or offer for sale of DP and all products containing the substance (Canada, 2019b).
European Union	In 2018, based on an Annex XV dossier and Risk Management Options Analysis prepared by the United Kingdom, DP (including its *syn-* and *anti*-isomers) were identified as SVHC and added to the REACH Candidate List as they are considered to be very persistent and very bioaccumulative substances (ECHA, 2017a). Moreover, suppliers of articles containing a SVHC in a concentration above 0.1% (weight by weight) have to provide recipients of the article with sufficient information to allow the safe use of the article. As a minimum, the name of the substance in question has to be communicated. Upon request from a consumer, the supplier has to provide safety data sheet, within 45 days. Based on its intrinsic properties in combination with high volume and widespread use, ECHA recommended in October 2019 to include DP in Annex XIV of the REACH Regulation (List of Substances Subject to Authorization). To align risk management activities within the EU with the evaluation process under the Stockholm Convention, an Annex XV REACH restriction dossier for DP will be prepared. Norway is responsible for developing the restriction proposal which is expected to be submitted in April 2021. This will affect the process regarding possible inclusion of DP in REACH Annex XIV. There is no harmonised classification for DP (CAS 13560-89-9) in the EU, but 78 notifiers have classified the substance as Acute Toxicity Category 4, H332 Harmful if inhaled (ECHA, 2018).
New Zealand	DP is listed on New Zealand's Inventory of Chemicals but does not have its own approval under the Hazardous Substances and New Organisms Act. This means it can only be used as a component of products that are covered by group standards (Annex E information, New Zealand). [HYPERLINK]
Norway	In Norway, DP was added to the list of priority substances in January 2019 with a national goal to phase out the use by 2020 (Norwegian Environment Agency, 2019b).
Thailand	DP is not yet classified under the Hazardous Substance Act B.E. 2535 (1992). However, DP is regulated under the notification of the Ministry of Industry, Thailand on Account no 5.6. Manufacturers and importers are required to report imports of chemicals/products with tonnage above 1000 kg/year. At present, there is no data on available import volumes and usage in Thailand (Annex E information, Thailand)
United States of America	DP is listed under the Toxic Substances Control Act (inventory and is subject to the Chemical Data Reporting Rule, which requires manufacturers and importers to provide the United States Environmental Protection Agency with production, import and use volumes, as well as other relevant information (US EPA, 2020).
International Chemical Secretariat	DP has been listed on the International Chemical Secretariat's ChemSec Substitute It Now (SIN) List since 2014 (SIN List, 2020). The SIN List consisting of chemicals that have been identified by ChemSec as being SVHC, based on the criteria defined within REACH, the EU chemicals legislation.

Table 4. Detection in wastewater treatment, sludge and matrix from impacted sites and from manufacture/recycling sites

Matrix	Country/Region/Area	Year	Study site Type of location	Concentration			Comments	Reference
Wastewater treatment, sludge, impacted sites and from manufacture etc				***syn***	***anti***	***tot*DP**		
Wastewater	China	2010-2011	WWTP, Shanghai			50-1400 pg/L		Xiang et al., 2014
Soil	China	2009	E-waste recycling site			0.17-1990 ng/g dw		Xiao et al., 2013
Soil	China	2009	Near manufacturing plant			0.83-1200 ng/g		Wang et al., 2010b
Soil	China	2009	Manufacturing facility in Huai'an			5.11-13400 ng/g dw		Wang et al., 2010a
Soil	China	2011	Manufacturing facility in Huai'an			0.50–2315 ng/g		Zhang et al., 2015
Soil	China	-	E-waste disposal area in Guiyu	0.14–38 ng/g	0.42–107 ng/g	0.57–146 ng/g		Xu et al., 2017
Soil	China		E-waste recycling site	1081 ng/g	2246 ng/g	3327 ng/g		Yu et al., 2010
Soil	China		Areas surrounding the e-waste recycling sites	n.d. - 12.2 ng/g	n.d. - 36.3 ng/g	n.d. - 47.4 ng/g		Yu et al., 2010
Soil	China		Industrial areas	n.d. - 1.18 ng/g	0.03 - 3.47 ng/g	0.03 - 4.65 ng/g		Yu et al., 2010
Soil	China		Manufacturing areas			0.50–2,315 pg/g		Zhang et al., 2015
Sediment	Lake Ontario	2004	Near manufacturing plant			<310 ng/g dw		Qiu et al.,2007
Sediment core	Lakes Erie	1997-1998	Near manufacturing plant			0.061-8.62 ng/g dw		Sverko et al., 2008
Sediment core	Lake Ontario	1997-1998	Near manufacturing plant			2.23-586 ng/g dw		Sverko et al., 2008
Surficial sediments	Great Lakes, Canadian site	2002-2006	Near manufacturing plant			0.035-310 ng/g dw		Shen et al., 2011b
Suspended sediment	Niagara river	1980-2007	Near manufacturing plant			2.5-62 ng/g dw		Shen et al., 2011a
Sediment core	Lake Ontario		Near manufacturing plant			0.061-160 ng/g dw		Shen et al., 2011a

Matrix	Country/Region/Area	Year	Study site Type of location	Concentration			Comments	Reference
Wastewater treatment, sludge, impacted sites and from manufacture etc				***syn***	***anti***	***tot*DP**		
Surficial sediment core	Lake Ontario	2007	Near manufacturing plant			73-140		Yang et al., 2011
Sediment core	Lake Ontario	2006-2007	Near manufacturing plant			0.85-96		Shen et al., 2010
Sediment	China		Manufacturing facility in Huai'an			1.86-8.00 ng/g dw		Wang et al., 2010a
Sediment	China	2009	e-waste recycling site	520-1630 ng/g	1860-6630 ng/g			Zhang et al., 2011b
Riverine surface sediments	China	2013	e-waste recycling region in Taizhou	27 – 14280 pg/g dw	81 – 13410 pg/g dw	108 – 55270 pg/g dw	*anti*-Cl_{10}: nd - 2580 *anti*-Cl_{11}: 2 - 580	Zhou et al., 2017
Suspended sediment	China	-	e-waste recycling site	*13130 ± 2885 ng/g OC*	*65660 ± 11440 ng/g OC*		ng/g Organic Carbon	Wu et al., 2010
Surficial sediment	China	-	e-waste recycling site	*21820 ± 2160 ng/g OC*	*55320 ± 7140 ng/g OC*		ng/g Organic Carbon	Wu et al., 2010
Sediment	China		Manufacturing areas			0.32–20.5 ng/g dw		Zhang et al., 2015
Sewage sludge	Norway	2017	WWTP	2.1 ng/g	7.4 ng/g			Norwegian Environment Agency, 2018b
Sewage sludge	Norway	2018	WWTP	2.5 ng/g	11.8 ng/g			Norwegian Environment Agency, 2019a
Sewage sludge	Spain		WWTP			2.58-18.8 ng/g d.w.		Barón et al., 2012
Sludge	Spain	2010	Ebro and Llobregat river basins,			<0.06-18.8		Barón et al., 2014b

Matrix	Country/Region/Area	Year	Study site Type of location	Concentration			Comments	Reference
Wastewater treatment, sludge, impacted sites and from manufacture etc				***syn***	***anti***	***tot*DP**		
Sewage sludge, biosolids	United States of America	2006-2010	Municipal, North Carolina	2-24 ng/g d.w	5-29 ng/g d.w			Davis et al., 2012
Sewage sludge	Spain	2006	WWTP			2.45-93.8 ng/g d.w.		de la Torre et al., 2011a
Sludge	China	2013-2014	Sewage treatment plants (STP)	8.6 – 16 ng/g d.w	7.2 – 19.2 ng/g d.w			Wu et al., 2017
Air	Canada	2017-2018	e-waste recycling site, small facility	2–5.8 ng/m3	2.3–5.4 ng/m3	4.4–11 ng/m3		Gravel et al., 2019
Air	Canada	2017-2018	e-waste recycling site, medium facility	4.7–9.3 ng/m3	7.3–15 ng/m3	12–24 ng/m3		Gravel et al., 2019
Air	Canada	2017-2018	e-waste recycling site, large facility	12–18 ng/m3	22–34 ng/m3	34–53 ng/m3		Gravel et al., 2019

Table 5. Overview over available bioaccumulation data[1]

Species (tissue)	Country/Region/Area and Exposure	Tissue	BAF/BCF L/kg	BMF			TMF			Comments and Benchmark BMF/TMF	References
				syn	*anti*	*tot*DP	*syn*	*anti*	*tot*DP		
Aquatic organisms/food webs											
Fish/zoo plankton	Canada/Field	whole		<0.1-0.6	0.8-11						Tomy et al., 2007
Fish/diporeia (shrimp-like)	Canada/Field	whole		0.1-12	0.1-11						Tomy et al., 2007
Fish/zoo plankton	Canada/Field	whole					1.3	1.1		PBDEs	Kurt-Karakus et al., 2019
Fish/invertebrate	South China/Field	various					11.3	6.5	10.2	PBDEs and PCBs	Wu et al., 2010
Fish/invertebrate (seven species)	Huai'an China/Field	whole					3.1	1.9	2.2	DPMA, anti-Cl11-DP and anti-Cl10-DP	Wang et al., 2015
Fish (various)/crab	South China/Field	various				1.3-11.8			2.3*		Sun et al., 2015
Food web (fish, octopus, crab)	South China/Field	muscle				2.3-7.1				PBDEs, DDT and PCBs	Sun et al., 2017
Seal/algae (total nine species)	Antarctica	various					2.9	3.3	3.0	PCBs	Na et al., 2017
Skua (bird)/penguins	Antarctica	muscle (pectoralis)					18.9	21.5			Kim et al., 2015
Trout diet study	Laboratory	whole - liver		5.2	1.9					Juvenile rainbow trout, exposed for 49 days through spiked food , and depuration for 112 days with unspiked food.	Tomy et al., 2008
Fish diet study	Laboratory	serum		1.06	1.23					Carps were exposed by spiked food for 28 days and depurated with non-spiked food for 84 days. Steady-state was only reached in serum. Several tissues were measured, and other tissues had longer depuration half-life, but only serum reached	Tang et al., 2018

Species (tissue)	Country/Region/Area and Exposure	Tissue	BAF/BCF L/kg	BMF			TMF			Comments and Benchmark BMF/TMF	References
				syn	*anti*	*tot*DP	*syn*	*anti*	*tot*DP		
										equilibrium and had BMF above 1.	
Carp water exposure study (lab-microcosms) BCF	Laboratory BCF	muscle	*syn*-DP 5700 *anti*-DP 9300							BCF based on wet weight and ratio of rate constants, 32 days exposure and 32 days depuration. Water concentration was 0.054-011 for syn- DP and 0.086-0.14 ng/L for anti-DP. Rate constants (days): syn-DP anti-DP k_s 0.63 0.89 k_e 0.11 0.093 $t_{1/2}$ 6.3 7.2	Wang et al., 2019
Terrestrial organisms/food webs											
Frog/insect	South China/Field	muscle/whole		2.7	1.8	2.1				BMFs for PBDEs and anti-Cl11-DP detected	Wu et al., 2018
Owl/sparrow	China, Beijing	muscle		12	6.8	10				PBDEs, PCBs, HBCD, ppDDE	Yu et al., 2013
Owl/brown rat	China, Beijing	muscle		2.4	1.9	2				PBDEs, PCBs, HBCD, ppDDE	Yu et al., 2013
Sparrow/common kestrel	China, Beijing	muscle		0.31	0.35	0.32				PBDEs, PCBs, HBCD, ppDDE	Yu et al., 2013
Brown rat/common kestrel	China, Beijing	muscle		0.06	0.10	0.06				PBDEs, PCBs, HBCD, ppDDE	Yu et al., 2013
Apple snail/rice plant	South China/Field			3.1	2.3					PBDEs	She et al., 2013

*Non-significant

[1] Definitions:

- Bioconcentrationfactor (BCF; point) – describes uptake and accumulation of chemical from water only.
- Bioaccumulation factor (BAF; point) – describes uptake and accumulation of chemical from all sources (water, sediment, diet, etc.) relative to amount of chemical (exposure) in water.
- Biota- sediment accumulation factor (BSAF; point) – describes uptake and accumulalation of chemical from all sources relative to amount of chemical (exposure) in sediment.
- Biomagnification factor (BMF; slope) – describes rate of change of chemical concentration in organisms separated by a single trophic level step (ΔTL=1) on a food chain.
- Trophic magnification factor (TMF; slope) – describes rate of change of chemical concentration in organisms that occupy successively higher trophic levels (ΔTL>1) in a food web.

Table 6. Abiotic monitoring data for Dechlorane Plus in remote locations (adopted from ECHA 2017d and added new literature)

Matrix	Country/Region/Area	Year	Study site/ type of location	Concentration			fanti	Detection frequency %, syn; anti-DP	Comment	Reference
				syn	*anti*	*tot*DP				
Atmosphere	Canada	2006 - 2007?	Alert, High Arctic			<0.05 - 2.1 pg/m^3			Primarily associated with particles	Xiao *et al.*, 2012
	Tibet, China	2006 - 2008	Tibetan Plateau (Nam Co), Remote Mountain Area			ND			ND in pre-screening suggested to be due to fewer particulates reaching the station	
Atmosphere	Greenland	2009	Transect in East Greenland Sea			0.05 - 4 pg/m^3			- Mainly detected in the particulate phase - In the Atlantic, the highest concentration was observed in the English Channel originating from continental air passing Western Europe - The fractional abundance of syn-DP increased with decreasing northern latitude from 0.37 to ca. 0.67, showing a stereoselective depletion of anti-DP	Möller *et al.*, 2010
	Atlantic	2008	Transect in northern and southern Atlantic Ocean							
Atmosphere	China	2010	Transect from East China Sea to Arctic			0.01 - 1.4 pg/m^3			Mainly detected in the particulate phase	Möller *et al.*, 2011
		2010 - 2011	Transect in Pacific Ocean			1.7 - 11 pg/m^3				Möller *et al.*, 2012

Matrix	Country/Region/Area	Year	Study site/ type of location	Concentration			*f*anti	Detection frequency %, syn; anti-DP	Comment	Reference
				syn	*anti*	*tot*DP				
			Transect in Indian Ocean			0.26 - 2.1 pg/m^3				
			Transect in Southern Ocean			0.31 pg/m^3				
Atmosphere	Arctic	2012 - 2013	Arctic (78.22°N 15. 65°E)	Mean 0.29 (±0.04) pg/m3	Mean 1.1 (±0.19) pg/m3	0.05 - 5 pg/m^3	0.43 - 0.9 (mean 0.75)	91; 91	The samples represent the atmospheric particulate fraction collected on quartz fibre filters (2.2 µm cut-off)	Salamova *et al.*, 2014
Atmosphere	Sweden	2009 - 2010	Råö			0.18 - 0.52 pg/m^3				Kaj *et al.*, 2010
			Aspvreten			0.12 - 0.23 pg/m^3				
	Northern Finland		Pallas, Arctic			0.016 - 0.047 pg/m^3				
Atmosphere	Arctic								It does not cite articles beyond the ones already summarised here	Vorkamp *et al.*, 2014
Atmosphere	Northeast Greenland	2012	Station Nord	Mean 2.32 (<1 - 9.0) pg/m^3	Mean 5.24 (<1 - 33.1) pg/m^3					Vorkamp *et al.*, 2015

Matrix	**Country/Region/Area**	**Year**	**Study site/ type of location**	**Concentration**			***f*anti**	**Detection frequency %, syn; anti-DP**	**Comment**	**Reference**
				syn	*anti*	*tot*DP				
Atmosphere	Greenland, Arctic	2014-2016	Villum Research Station			Mean 4.2 pg/m^3 Max. 31.7 pg/m^3				Vorkamp *et al.*, 2019
		2014				Mean 0.64 pg/m^3 Max. 5.5 pg/m^3				
Atmosphere	Northern Sweden	2009 - 2010	Abisko in the Arctic			Max. 5.7 ng per sample	Mean 0.25		- The higher flux was found at the more remote site - It suggests isomer-selective degradation or isomerization during long range transport to the more remote site - The *f*anti at the sub-Arctic site was similar to that in commercial products, which may indicate proximity to a local source	Newton *et al.*, 2014
			Krycklan in the sub-Arctic			Max. 0.16 ng per sample	Mean 0.62			
Atmosphere	All continents except Antarctica	2005 (also 2006?)	25 sites			ND - 348 pg/m^3			- The highest level being for Cape Grim, Tasmania where population density is very low	Sverko *et al.*, 2010

Matrix	Country/Region/Area	Year	Study site/ type of location	Concentration			*f*anti	Detection frequency %, syn; anti-DP	Comment	Reference
				syn	*anti*	*tot*DP				
									- Also detected in north Alaska and Svalbard	
Seawater	Greenland	2009	Transect in East Greenland Sea			< LOD - 1.3 pg/L			Mainly detected in the particulate phase	Möller *et al.*, 2010
	Atlantic	2008	Transect in northern and southern Atlantic Ocean							
Seawater	China	2010	Transect from East China Sea to Arctic			0.006 - 0.4 pg/L				Möller *et al.*, 2011
Soil	Norway	-	Ny-Ålesund, Svalbard, Arctic	Mean 0.284 (0.094 - 1.01) µg/kg dw	Mean 0.042 (0.012 - 0.105) µg/kg dw		0.18		Low *f*anti values found in water, sediment, soil may reflect degradation of anti-DP during long-range transport, possibly by UV	Na *et al.*, 2015
Seawater				Mean 61 (22 - 116) pg/L	Mean 32 (85 - 648) pg/L		0.36			
Sediment				Mean 0.270 (0.085 - 0.648) µg/kg dw	Mean 0.073 (0.023 - 0.228) µg/kg dw		0.21			

Matrix	**Country/Region/Area**	**Year**	**Study site/ type of location**	**Concentration**			***f*anti**	**Detection frequency %, syn; anti-DP**	**Comment**	**Reference**
				syn	*anti*	*tot*DP				
Sediment	Norway	2009	Kongsfjorden, Svalbard, Norwegian Arctic	ND - 5.4 pg/g dw (mean 1.4 ± 1.5 pg/g dw)	ND - 15.9 pg/g dw (mean 4.5 ± 4.3 pg/g dw)			78; 94	- No clear spatial trend between the outer and inner fjord - Plausible that both glacial runoff and oceanic currents play a role in introducing DP to the fjord sediments - Relatively low fractional abundance of the syn-DP isomer indicates the long-range transport of this chemical to this Arctic site	Ma *et al.*, 2015

Table 7. A comparison of atmospheric concentrations (in pg m^{-3}, sum of gaseous and particulate phases) of PBDEs, HBB, PBT, DPTE and DP over the global oceans and their marginal seas (na = not analyzed, nd = not detected) from Möller et al. (2012).

	year[a]	BDE-47	BDE-209	ΣPBDEs	HBB	PBT	DPTE	DP
Atlantic Ocean	2008	0.57−8.3	na	0.86−6.4	na	na	na	na
Atlantic Ocean	2008	0.18−2.3	na	0.43−3.3	0.10−11	0.01−0.05	0.10−2.3	0.05−1.6
Atlantic Ocean (North Sea)	2010	0.10−0.79	nd−9.4	0.31−10.7	0.09−6.3	nd−0.24	nd−2.5	0.13−22
Pacific Ocean	2010	0.04−0.11	nd−2.0	0.22−2.3	0.10−2.5	0.12−0.64	0.18−0.41	0.01−0.86
Pacific Ocean[b]	2003	0.88−17	<0.5−27	1.4−37	na	na	na	na
Pacific Ocean (East Asian Seas)	2010	0.07−0.76	0.13−3.9	0.31−8.1	0.26−5.9	0.36−4.53	0.26−5.9	0.52−0.75
Pacific Ocean (East Asian Seas)[b]	2003	<0.16−112	<0.50−29	2.3−199	na	na	na	na
Pacific Ocean (East and South China Seas)	2008	0.41−13	na	2.9−29	na	na	na	na
Pacific Ocean (East Indian Archipelago and Philippine Sea)	2010/11	0.14−0.32	nd−4.0	0.14−4.6	3.7−19	0.71−2.2	0.44−2.3	1.7−11
Indian Ocean	2008	0.57−8.3	na	1.15−13	na	na	na	na
Indian Ocean	2004/05	<3.4−13	<0.6	1.5−16	na	na	na	na
Indian Ocean	2010/11	nd−0.49	nd−6.5	nd−6.6	0.15−26	nd−2.8	nd−1.1	0.26−2.1
Arctic Ocean	2010	0.03−0.04	nd−4.0	0.07−4.1	0.16−0.42	0.22−0.79	0.10−0.19	0.05−0.44
Arctic Ocean[b]	2003	<0.16-31	<0.50−41	<2.58−61	na	na	na	na
Arctic Ocean (Greenland Sea)	2009	0.06−0.95	nd−0.07	0.09−1.8	0.08−0.66	nd−0.02	0.01−1.7	0.02−4.2
Southern Ocean	2008	0.58	na	0.78	0.32	0.02	0.04	0.07
Southern Ocean	2010/11	0.08	nd	0.13	0.12	nd	nd	0.31

[a]Year of sampling. [b]Only aerosols.

Table 8. A comparison of concentrations of *syn*- and *anti*-DP in air samples from Arctic stations, as presented in Vorkamp et al. 2019.

Location	Year	Mean ΣDP concentration (pg/m^3)	Maximum ΣDP concentration (pg/m^3)	Reference
Villum Research Station	2014-2016	4.2	31.7	This study (all samples)
Villum Research Station	2014	0.64	5.3	This study, monthly samples
Villum Research Station	2012	6.7	41	Vorkamp et al. (2015)
Pallas, Finland	2013/2014	0.039	0.061	Haglund et al. (2016)
Little Fox Lake, Yukon, Canada	2011-2014	~ 0.25	~ 1.8	Yu et al. (2015)
Longyearbyen, Svalbard *	2012/2013	1.2	5.0	Salamova et al. (2014)
Alert, Canada	2007	~ 0.75	2.1	Xiao et al. (2012)

* Particle phase only. DP is mainly associated with particles (Hoh et al., 2006).

Table 9. Concentrations (ng/g lipid weight) and detection frequencies (DF) of *syn*- and *anti*-DP in biota samples from Greenland (Vorkamp et al., 2019). Lipids (%) describes mean lipid content of the samples. Concentrations < LOQ were set to 0 in the calculations of means.

Species		syn-DP			anti-DP		
	Lipids (%)	DF (%)	Mean	Range	DF (%)	Mean	Range
Arctic char	0.69	0	<0.13	<0.13	50	0.047	<0.030-0.19
Glaucous gull (Thule)	5.3	100	0.22	0.076-0.35	100	0.89	0.34-1.2
Ringed seal (Thule)	92	0	<0.018	<0.018	0	<0.017	<0.017
Harp seal	95	25	0.008 [a]	<0.018-0.032	25	0.014 [a]	<0.017-0.058
Hooded seal	92	50	0.013 [a]	<0.017-0.033	50	0.019	<0.017-0.045
Bearded seal	88	20	0.004 [a]	<0.017-0.019	20	0.009 [a]	<0.015-0.045
Narwhal	90	0	<0.065	<0.065	12.5	0.012 [a]	<0.039-0.096
Killer whale	98	9.1	0.040 [a]	<0.038-0.44	18.2	0.19	<0.037-2.1
Glaucous gull (East)	5.3	87.5	0.24	<0.55 [b]; 0.079-0.54	100	0.93	0.39-2.1
Ringed seal (East)	90.6	0	<0.014	<0.014	50 [c]	0.076	<0.013-0.17

[a] value near or below detection limits; [b] very low sample intake (0.31 g); [c] detected in two out of four samples, in the fifth sample the peak could not be integrated.

Table 10. Measured concentrations in aquatic biota

Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
Invertebrates										
Mussel (species not specified) (n=2)	Soft parts	Canada	-	Niagara River area	Affected	Site 1 ~2 µg/kg ww Site 2 ~0.8 µg/kg ww	Site 1 ~2 µg/kg ww Site 2 ~1 µg/kg ww	Site 1 ~4 µg/kg ww Site 2 ~1.8 µg/kg ww	- Analysis by GC-HRMS - Not known if mussels were depurated prior to analysis - Values read from a graph - It appears that two different locations were involved, with one mussel representing each site	Kolic *et al.* (2009)
Blue Mussel (*Mytilus edulis*) (n unknown)	Soft parts	Iceland	2011	Fossá river estuary, Hvalfjörð ur	Remote	< LOD	< LOD		- Analysis by GC-MS - LOD: presumably 0.003/4 µg/kg ww for both isomers - Not known if mussels were depurated prior to analysis	Schlabach *et al.* (2011)
		Norway	-	Receiving water from Åse WWTP, Ålesund	Affected	0.017-0.023 µg/kg ww	0.018-0.019 µg/kg ww	0.035-0.042 µg/kg ww		
Fish										
Barbel (*Barbus barbus*) Wels Catfish (*Silurus glanis*) Common Carp (*Cyprinus carpio*) (n unknown)	Not stated	Spain	-	Ebro river basin	Affected			Median 0.88 µg/kg lw Range <LOD-2.24 µg/kg lw	- Analysis by GC-NCI-MS-MS - LOD (µg/kg lw): Anti-DP: 0.0023 Syn-DP: 0.0055 - Presumably a subset of the data reported by Santín *et al.* (2013)	Barón *et al.* (2012)
Fish (various species) (n=48)	Whole body	Spain	2010	Llobregat river basin	Affected			0.57-4.86 µg/kg lw	- Analysis by GC-MS - LOD (µg/kg lw): Anti-DP: 0.0023 Syn-DP: 0.0055 - The study included four Wels Catfish (*Silurus glanis*) caught in the Ebro river basin	Santín *et al.* (2013)
				Júcar river basin				<LOD-0.59 µg/kg lw		
				Ebro river basin				0.11-1.28 µg/kg lw		

Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
				Guadalquivir river basin				0.06-1.91 µg/kg lw		
Lake Trout (*Salvelinus namaycush*) (from Lake Superior (n=3), Lake Huron (n=5), Lake Ontario (n=5)) Whitefish (*Coregonus clupeaformis*) (from Lake Erie (n=5), Lake Ontario (n=5))	Dorsal muscle	Canada	1999-2002	Lake Superior, Lake Huron, Lake Ontario, Lake Erie	Affected			Range 0.061-2.600 µg/kg lw	- Analysis by GC-HRMS - Detected in all samples - Fish from Lake Ontario had higher concentrations compared to those from the other lakes - Most fish samples had *f*anti values below the highest value of technical products (no difference was observed between the two fish species)	Shen *et al.* (2010)
Walleye (*Stizostedion vitreum)*	-	United States of America (USA)	1980-2000	Lake Erie	Affected			Range 0.14-0.91 µg/kg lw	- Analysis by GC-MS - LOQ (µg/kg lw): Anti-DP: 0.05 Syn-DP: 0.12 - Most of the muskelunge samples were >7 years old	Hoh *et al.* (2006); Houde *et al.* (2014)
Yellow Perch (*Perca flavescens*) (n=29)	Whole body							ND		
Northern Pike (*Esox lucius*) (n=11)	Liver					Range ND-9.1 µg/kg lw (Detected in 45 % of samples)	Range ND-2 µg/kg lw (Detected in 45 % of samples)			
Muskellunge (*Esox muskellunge*) (n=10)	Liver							Mean 6.2±3.6 µg/kg lw (one fish contained 37.4 µg/kg lw) (Detected in at least 90% of samples)		
Lake Trout (*Salvelinus namaycush*) (n=5 per year)	Whole body	Canada	1979 1983 1988 1993 1998 2004	Lake Ontario (north of Main Duck Island)	Affected			Mean per year 0.31±0.07 to 0.85±0.20 µg/kg ww (2.3±0.6 to 7.2±1.3 µg/kg lw)	- Analysis by GC-MS - LOQ 0.01 µg/kg ww - Sampled fish were four to five years old - Stable isotope analysis showed that trophic status and food sources were highly variable over time	Ismail *et al.* (2009)

Organism		Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
							syn	*anti*	*tot*DP		
European Eel (*Anguilla anguilla*) Glass eels (n=100, split into 10 samples)		Whole body or muscle	France	-	The French Atlantic coast	Affected			Glass eels: <0.02-0.32 µg/kg ww (LOD-31.8 µg/kg lw)	- Analysis by GC-MS - LOD (µg/kg ww): Anti-DP: 0.017 Syn-DP: 0.0053 - Levels were similar to American Eels, and probably reflect diffuse exposure - The isomer ratio changes over the life cycle: The syn-isomer predominates (>80%) in glass, elvers and yellow eels, but its contribution drops to 40% in silver (fully adult) eels that have stopped feeding	Sühring *et al.* (2013 and 2014)
European Eel (*Anguilla anguilla*) Elvers (n=30), yellow (n=30), silver eels (n=12)			Germany	-	River Vidå, River Elbe and Rivers Elbe and Rhine	Affected			Elvers: <0.02-0.46 µg/kg ww (<LOD-33.8 µg/kg lw) Yellow eels: 0.013-0.50 µg/kg ww (0.14±0.008 µg/kg lw) Silver eels: 0.017-0.38 µg/kg ww (0.17±0.19 µg/kg lw)		
American Eel (*Anguilla rostrata*)	Glass eels (n=37, pooled into three samples)	Whole body or muscle	Canada	2007-2008	Baie des Sables, Matane, Quebec	Affected			<0.02 µg/kg ww	- Analysis by GC-MS - LOD (µg/kg ww): Anti-DP: 0.017 Syn-DP: 0.0053 - Levels were similar to European Eels and probably reflect point source as well as diffuse exposure - The isomer ratio changes over the life cycle: The syn-isomer predominates (>70%) in yellow eels, but its contribution drops to 44 % in silver (fully adult) eels that have stopped feeding - DPMA was detected in yellow and silver eels from the same area	Sühring *et al.* (2014); Byer *et al.* (2013)
	Young yellow eels (n=10)				The Saint Lawrence River				0.10-0.69 µg/kg ww (1.7 ± 0.92 µg/kg lw)		
	Yellow eels (n=15, muscle)				Lake Ontario and the upper Saint Lawrence River				0.19±0.086 to 0.29±0.20 µg/kg ww (0.90 ± 0.41 to 0.17±0.19 µg/kg lw)		
	Silver eels				Lake Ontario				0.067±0.048 µg/kg lw		
Arctic Char (*Salvelinus alpinus*) (12 fish analysed as a pooled sample)		Muscle	Faroe Islands	-	á Mýranar lake	Remote	< LOD	< LOD		- Analysis by GC-MS - LOD (µg/kg ww): Presumably 0.003/4 for both isomers	Schlabach *et al.* (2011)

Organism		Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
							syn	*anti*	*tot*DP		
Perch (*Perca fluviatili*)	n=1 from Helsinki and n=5 Pyhäjärvi	Muscle	Finland	-	Helsinki (Old City Bay) and Pyhäjärvi, Tampere	Affected	0.0038 µg/kg ww in one composite sample, all others < LOD	0.0011 and 0.0030 µg/kg ww in two composite samples, all others < LOD		- Analysis by GC-MS - LOD (µg/kg ww): Anti-DP: 0.001-0.003 Syn-DP: 0.002-0.004 - Composite sample	
	n unknown		Sweden		Riddarfjärden and Stora Essingen at Lake Mälaren, Stockholm		< LOD	< LOD		- Analysis by GC-MS - LOD (µg/kg ww): Anti-DP: 0.001-0.003 Syn-DP: 0.002-0.004 - 6-10 individuals per composite sample	
Striped Bass (*Morone saxatilis*) (n=1) Tilapia (*Oreochromis mossambicus*) (n=1) Cod (*Gadus morhua*) (n=1) Atlantic Salmon (*Salmo salar*)] (n=1)		Muscle	Taiwan, Province of China	-	Two Super-markets in Chung-Li city	Affected	Range 0.038-0.273 µg/kg lw	Range 0.034-0.300 µg/kg lw		- Analysis by GC-MS - LOD: 0.0003 µg/g lw for both isomers - Cod and salmon were imported while the other two species were locally caught - The highest concentrations occurred in the bass	Chen *et al.* (2014)
Fish (15 marine species) (n=20)		Muscle	Japan	2011	Super-markets in Osaka	Affected			Up to 0.0142 µg/g ww	- Analysis by GC-MS - LOD 0.0002 µg/kg ww - Detected in 18 out of 20 samples	Kakimoto *et al.* (2012)
Common Mullet Oriental Goby Steed Barbel Temperate Sea Bass Crucian Carp (Latin names not provided)		Muscle	Republic of Korea	2008	22 rivers across South Korea	Overall	Range 0.17 – 30 µg/kg lw	Range 0.44 – 97 µg/kg lw	Average 24.5 (range 0.61-126) µg/kg lw	- Analysis by GC- high resolution MS - Fish were sampled twice at each site and several individual fish carcasses were combined and homogenized to provide a pooled sample - Both isomers were consistently detected in all fish samples regardless of	Kang *et al.* (2010); Kang *et al.* (2009) [ABST]
						Rural-industrial (3 sites) and Rural (4 sites)			1.4±1.0 µg/kg lw		

Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
					Urban-industrial (15 sites)			36.1±35.3 ng/g lw	sampling sites and fish species - Mean concentrations at the urban sites were around 25 times greater than those at the rural sites - The anti-DP isomer was dominant in all samples - The mean *f*anti value (0.67 ±0.060) was significantly lower than that of the technical product (0.75) (p = 0.032) suggesting that the syn- isomer may be more bioaccumulative There is no manufacturing facility in South Korea	
Mud Carp (*Cirrhinus molitorella*) (n=10) Northern Snakehead (*Channa argus*) (n=10)	Muscle, liver & brain	China	2009	Natural pond at an e-waste recycling site, South China	Affected		Anti-DP-1Cl Median 0.01-5.63 µg/kg ww Anti-DP-2Cl 0.01 µg/kg ww	Mud Carp (median) Muscle: 0.38 µg/kg ww Liver: 9.55 µg/kg ww Brain: 18.26 µg/kg ww Northern Snakehead (median) Muscle: 0.76 µg/kg ww Liver: 92.0 µg/kg ww Brain: 11.8 µg/kg ww	- Analysis by GC-MS - LOD (µg/kg ww): Anti-DP: 0.00052 (muscle) to 0.024 (brain) Syn-DP: 0.0012 (muscle) to 0.055 (brain) - Both species are associated with benthic environments - Both isomers were detected in all samples - The median sediment concentration (total isomers) was above 3,000 µg/kg dw - Higher levels of the anti-isomer were detected in the brain than liver or muscle for Mud Carp whereas liver accumulated more of both isomers in Northern Snakehead - Lipid-normalized concentrations indicated preferential distribution to	Zhang *et al.* (2011a)

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Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
									liver in both species, suggesting that hepatic proteins might be important in the accumulation of this substance - It appeared that there was enrichment of the syn- isomer in all tissues (except Northern Snakehead brain) compared to levels in sediment and the technical product - The study shows that both isomers can cross the blood-brain barrier in fish - Anti-DP-1Cl was detected in 100% of liver and 80% of muscle samples - Anti-DP-2Cl was detected in one muscle sample of Mud Carp - Both anti-DP-1Cl and anti-DP-2Cl were detected in all five sediment samples collected at the same time (range 6.32-25.0 µg/kg dw, median 12.0 µg/kg dw for anti-DP-1Cl and range 0.42-0.83 µg/kg dw and median 0.64 µg/kg dw for anti-DP-2Cl)	
Mud Carp (*Cirrhinus molitorella*) (n=3) Northern Snakehead (*Ophicephalus argus*) (n=3)	Blood serum	China	2010	Electronics waste recycling site in South China	Affected			<u>Mud Carp</u> Mean 0.3 µg/kg ww Mean *f*anti = 0.44 <u>Northern Snakehead</u> Mean 4.6 µg/kg ww Mean *f*anti = 0.56	- Analysis by GC-MS - LOD: 0.009-0.026 µg/kg ww - Six individuals per pooled sample - Each pooled sample was divided into 2 subsamples for analysis - The fanti in both species was significantly lower	Zeng *et al.* (2014b)

Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
								Both species Range 0.3-5.1 µg/kg ww (47-727 µg/kg lw)	(p<0.001) than that in sediments from the area ($f$anti=0.755) - Detected in all pooled samples	
Crucian Carp (*Carassius carassius*) Common Carp (*Cyprinus carpio*) Grass Carp (*Ctenopharyngodon idellus*) Sharpbelly (*Hemiculter leucisculus*) Pond Loach (*Misgurnus anguillicaudatus*) (n=18, pooled samples)	Muscle	China	2010	Liaohe River, Liaoning province (6 sites)	Affected			Mean 223 ng/kg lw Median 215 ng/kg lw Range ND-470 ng/kg lw	- Analysis by GC-MS - Detected in 17 out of 18 pooled samples	Ren *et al.* (2013)
Bleeker (*Pseudolaubuca sinensis*) (n=12) Loach (*Misgurnus anguillicaudatus*) (n=7) Crucian Carp (*Carassius auratus*) (n=9) Common Carp (*Cyprinus carpio*) (n=8) Northern Snakehead (*Channa argus*) (n=3)	Muscle	China	2010	Beijing-Hangzhou Grand Canal (downstream of the discharge point of the Chinese manufacturing facility), Huai'an, Jiangsu province	Affected			Mean 764 (range of mean for each species: 56.8-1110) µg/kg ww Mean 67500 (range of mean for each species: 2760-96800) µg/kg lw	- Analysis by GC- high resolution MS - LOD (µg/kg ww): Anti-DP: 0.135 Syn-DP: 0.120 - Five fish were pooled into composite sample for each species (except Northern Snakehead) - The highest mean concentrations were 1.1 mg/kg ww in Common Carp and 97 mg/kg lw in Bleeker	Wang *et al.* (2013)
Mosquito Fish (*Gambusia affinis*) (n=11) Paradise Fish (*Macropodus opercularis*) (n=9)	Whole fish	China	2010	Dinghu Mountain (reference site)	Rural		Anti-DP-1Cl < LOD (0.09 µg/kg lw)	34 fish, 12 composites Medians per species 1.7-8.4 µg/kg lw	- Analysis by GC-MS - LOD (µg/kg lw): Anti-DP: 0.59 Syn-DP: 0.14	Mo *et al.* (2013)

Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
Chinese Hooksnout Carp (*Opsariichthys bidens*) (n=18). Chinese False Gudgeon (*Abbottina rivularis*) (n=10) Nichols' Minnow (*Nicholsicypris normalis*) (n=6) Chinese Bitterling (*Rhodeinae*) (n=9)								Overall range 0.96-8.8 µg/kg lw	- Fish were pooled into composite sample for each species at each site - The e-waste site is in a heavily industrialized area - The reference site is in a relatively non-contaminated agricultural area - Anti-DP-2Cl was not detected in any sample (LOD: 0.01 µg/kg lw)	
				E-waste recycling site in the Pearl River Delta, Guangdong Province	Affected		<u>Anti-DP-1Cl</u> Range 2.4-14 µg/kg lw	29 fish, 9 composites Medians per species 79-410 µg/kg lw Overall range 60-420 µg/kg lw		
Greenland Shark (*Somniosus microcephalus*) (n=15)	Liver	Iceland	2001-2003	Female sharks caught in a commercial fishery in the waters around Northeast Atlantic	Remote				- The paper provides quantitative data on three target compounds that were "routinely" detected in the liver samples, but does not comment on the concentrations or detection frequencies of the other substances that were included in the analysis (including Dechlorane Plus) - In summarising this study, Vorkamp & Rigét (2014) stated that Dechlorane Plus was "not detected", but this might be misleading	Strid *et al.* (2013)
Brown trout (*Salmo trutta*)	Fillet	Norway	2017	Lake Mjøsa	Urban	4.5 µg/kg ww 530 µg/kg lw	4.9 µg/kg ww 580 µg/kg lw			Norwegian Environment Agency (2018c).
Smelt	Fillet	Norway	2017	Lake Mjøsa	Urban	6.8 µg/kg ww 660 µg/kg lw	9.6 µg/kg ww 940 µg/kg lw			Norwegian Environment Agency (2018c)
Brown trout (*Salmo trutta*)	Fillet	Norway	2017	Eikdalsvatnet	Rural	17.8 µg/kg ww 1800 µg/kg lw	47 µg/kg ww 4880 µg/kg lw			Norwegian Environment Agency (2018c).

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Organism	Tissue	Country /Region/ Area	Year	Study site	Type of location	Concentration			Comment	Reference
						syn	*anti*	*tot*DP		
Brown trout (*Salmo trutta*)	Fillet	Norway	2017	Femunden	Rural	4.5 µg/kg ww 530 µg/kg lw	4.9 µg/kg ww 580 µg/kg lw			Norwegian Environment Agency (2018c).

Table 11. Detection of Dechlorane monoadduct (DPMA) in environmental samples

Matrix		Country/Region/Area	Year	n	Concentration			Comment	Reference
					1,5-DPMA	1,3-DPMA	ΣDP		
Lake trout		Canada, Lake Ontario	2000-2003	4	nd	34 ± 43 ng/g lw			Sverko *et al.*, 2010
Plankton		Canada, Lake Ontario	2000-2003	1	nd	199 ng/g lw	2.05 ng/g lw		Tomy *et al.*, 2013
Diporeia				1	nd	56.1 ng/g lw	5.87 ng/g lw		
Alewife				2	7.9, 15.1 ng/g lw	3.40, nd ng/g lw	0.102, 0.082 ng/g lw		
Smelt				2	nd	5.9, 7.8 ng/g lw	0.01, 0.026 ng/g lw		
Sculpin				3	25.8, 22.2, 21.7 ng/g lw	16.4, 24.3, 101 ng/g lw	1.36, 2.91, 0.502 ng/g lw		
Trout				4	nd	0.50, 0.12, 0.22, 0.41 ng/g lw	0.107, 0.062, 0.076, 0.576 ng/g lw		
European eels	Glass eels	France, the French Atlantic coast	-	10 (pooled samples)	< LOD		<LOD - 0.32 ng/g ww <LOD - 31.8 ng/g lw	100 European glass eels were purchased from a glass eel distributer and combined into ten samples	Sühring *et al.*, 2014
	Elvers	Germany, the river Vidå	-	10 (pooled samples)	< LOD		<LOD - 0.46 ng/g ww <LOD–33.8 ng/g lw	Data for elvers and adult European eels were previously published in Sühring *et al.* (2013)	
	Yellow eels	Germany, the river Elbe	-	30	< LOD		0.041 ± 0.027 ng/g ww 0.14 ± 0.085 ng/g lw		
	Silver eels	Germany, the river Elbe and Rhine	-	20	< LOD		0.043 ± 0.048 ng/g ww 0.17 ± 0.19 ng/g lw		
American eels	Glass eels	Canada, Baie des Sables	-	3 (pooled samples)	< LOD		< LOD	37 American glass eels were pooled into 3 samples	
	Young yellow eels	Canada, the Saint Lawrence River	-	20	<LOD–0.037 ng/g ww <LOD–0.37 ng/g lw		0.17 ± 0.092 ng/g ww 1.7 ± 0.92 ng/g lw		
	Yellow eels	Canada, Lake Ontario	-	7	0.070 ± 0.019 ng/g ww		0.19 ± 0.086 ng/g ww		

Matrix		Country/Region/Area	Year	n	Concentration			Comment	Reference
					1,5-DPMA	1,3-DPMA	ΣDP		
					0.33 ± 0.090 ng/g lw		0.90 ± 0.41 ng/g lw		
	Yellow eels	Canada, the Saint Lawrence River	-	6	0.10 ± 0.016 ng/g ww 0.48 ± 0.076 ng/g lw		0.29 ± 0.20 ng/g ww 1.4 ± 0.95 ng/g lw		
	Silver eels	Canada, Lake Ontario	2007-2008	10	n.a.		n.a.	Data for American silver eels were previously published in Byer *et al.* (2013)	
	Silver eels	Canada, Lake Ontario	2007-2008	10	n.a. 0.37 ± 0.57 pg/g lw		n.a. 66.9 ± 48.1 pg/g lw		
Common carp		China, the Beijing-Hangzhou Grand Canal	2010	7	14.2 ± 3.1 ng/g lw		85700 ± 3300 ng/g lw	Not specified whether 1,5-DPMA or 1,3-DPMA (or both) were measured	Wang *et al.*, 2015
Snakehead				2	65.5 ± 14.8 ng/g lw		92600 ± 1600 ng/g lw		
Crucian carp				6	29.2 ± 4.5 ng/g lw		64400 ± 3700 ng/g lw		
River snail				25	31.4 ± 7.8 ng/g lw		10500 ± 2600 ng/g lw		
Bleeker				7	43.6 ± 9.7 ng/g lw		93000 ± 5600 ng/g lw		
Shrimp				14	17.3 ± 5.8 ng/g lw		19300 ± 500 ng/g lw		
Loach				5	13.3 ± 4.9 ng/g lw		3010 ± 330 ng/g lw		
Antarctic rock cod		Antarctica, King George Island	2010-2011	1 from each tissue		<LOD in all tissues		Samples include muscle, liver, spleen, stomach, stomach contents, blood, egg, and gallbladder	Wolsche *et al.*, 2015
Gentoo penguin				1 from each tissue		<LOD in all tissues		Samples include muscle, liver, spleen, stomach, stomach contents, lung, intestinal, intestinal contents, heart, gallbladder, genital, yolk, and egg white	
Brown Skua	Muscle			1		79.2 pg/g dw			
	Liver			1		53.6 pg/g dw			

Matrix		Country/Region/Area	Year	n	Concentration			Comment	Reference
					1,5-DPMA	1,3-DPMA	∑DP		
	Spleen			1		52.8 pg/g dw			
	Stomach			1		55.7 pg/g dw			
	Blood			1		<LOD			
	Ovarian			1		92.8 pg/g dw			
	Gallbladder			1		136 pg/g dw			
Baltic wild salmon		Latvia, the Daugava and Venta rivers	2012	25		Min 311 pg/g fw (8760 pg/g dw) Max 2169 pg/g fw (44,594 pg/g dw) Mean 969 ± 490 pg/g fw (22,571 ± 8747 pg/g dw) Median 861 pg/g fw (22,383 pg/g dw)		1,3-DPMA was the predominant DRC (Dechlorane-Related Compound) contributing up to 70% to the ∑DRC	Rajabova *et al.*, 2016
Peregrine falcon egg	**Overall**	Canada, the Canadian Great Lakes Basin	2007-2009	**12**	Geometric mean 30.2 ng/g lw		Geometric mean 36.4 ng/g lw	Not specified whether 1,5-DPMA or 1,3-DPMA (or both) were measured	Guerra *et al.*, 2011
	Terrestrial			10	Geometric mean 30.5 ng/g lw Range 1.2 - 1660 ng/g lw Median 62 ng/g lw		Geometric mean 38.4 ng/g lw Range 7.5 - 209 ng/g lw Median 43 ng/g lw		
	Aquatic			2	Geometric mean 28. 8 ng/g lw Range 3.8 - 218 ng/g lw Median 111 ng/g lw		Geometric mean 27.7 ng/g lw Range 6.3 - 122 ng/g lw Median 64 ng/g lw		
Peregrine falcon egg	**Overall**	Spain, Guadalajara in Central Spain and Bilbao on the North-Cantabric Coast of Spain	2003-2006	**13**	Geometric mean 21.1 ng/g lw		Geometric mean 1.78 ng/g lw	Not specified whether 1,5-DPMA or 1,3-DPMA (or both) were measured	
	Terrestrial			5	Geometric mean 2.19 ng/g lw Range 1.7 - 37 ng/g lw Median 2.5 ng/g lw		Geometric mean 0.6 ng/g lw Range 0.3 - 3.6 ng/g lw Median 0.6 ng/g lw		
	Aquatic			8	Geometric mean 71.2 ng/g lw Range n.d. - 469 ng/g lw		Geometric mean 2.81 ng/g lw		

Matrix		Country/Region/Area	Year	n	Concentration			Comment	Reference
					1,5-DPMA	1,3-DPMA	ΣDP		
					Median 51 ng/g lw		Range 0.4 - 17 ng/g lw Median 2.3 ng/g lw		

Table 12. Indoor air and dust

Matrix	Country/ Region/Area	Year	N	Study site Type of location	Mean (range) in ng/g, *air concentrations in pg/m3* detection frequency %			Comment	References
					Syn-DP	*Anti*-DP	Mean ΣDP		
Indoor air	Norway	2012	47	Residential living rooms	0.18 (<MLD-7.39) 2%	0.28 (<MLD-7.61) 4%	0.457		Cequier et. al., 2014
Indoor air	Norway	2012	6	School classrooms	<MLD 0%	<MLD 0%	-		Cequier et. al., 2014
Indoor air	Norway	2013-14	60	Residential living rooms	<1.2 (<1.2-150) 25%	<1.3 (<1.3-47) 15%			Tay et al., 2017
Indoor air	United Kingdom of Great Britain and Northern Ireland (UK)	2013-1015	20	Office	1.3 (<2.0-7.7) 5%	1.8 (<1.2-24) 5%			Tao et al., 2016
Indoor air	UK	2013-1015	15	Residential houses	<2.0 (<2.0-4.6, 7%	2.2 (<1.2-20) 20%			Tao et al., 2016
Indoor air	United States of America (USA)			Residential houses	0.37 (nd-4.0)	4.1(nd-23)			Venier et al., 2016
Indoor air	Canada			Residential houses	23 (nd-76)	25 (nd-243)			Venier et al., 2016
Indoor air	Czechia			Residential houses	-	65 (nd-65)			Venier et al., 2016
Dust	Norway	2012	48	Residential living rooms	9.07 (max 311) 92%	18.9 (max 590) 92%	27.97	Concentration of DP was negatively correlated with number of "Picture tube TVs", p= 0.018 and 0.04, for syn and anti-DP, respectively, and positive correlated with age of the woman (p=0.000)	Cequier et. al., 2014
Dust	Norway	2012	6	School classrooms	1.31 (max 3.13) 83%	3.68 (max 9.25) 100%	4.99		Cequier et. al., 2014
Dust	Norway	2013-14	61	Settled dust, residential homes	2.3 (<0.51-62) 48%	8.3 (<0.34-120) 72%			Tay et al., 2017

Matrix	Country/ Region/Area	Year	N	Study site Type of location	Mean (range) in ng/g, *air concentrations in pg/m3* detection frequency %			Comment	References
					Syn-DP	*Anti*-DP	Mean ΣDP		
Dust	UK	2013-1015	42	Office	60 (<0.26-640), 98%	210 (<0.15-2100) 98%	270		Tao et al., 2016
Dust	UK	2013-1015	30	Residential houses	3.6 (<0.26-28) 63%	21 (<0.15-170) 84%	24.6		Tao et al., 2016
Dust	Egypt, Cairo	2013	17	Residential houses	0.63 (<0.02-2.28) 71%	0.39 (<0.01-1.70) 47%			Hasan and Shoeib, 2015
Dust	Egypt, Cairo	2013	5	Workplaces	1.42 (0.02-2.88) 100%	0.37 (0.01-0.95) 80%			Hassan and Shoeib, 2015
Dust	Egypt, Cairo	2013	9	Cars	2.10 (<0.02-4.94) 100%	1.65 (0.01-0.95) 100%			Hassan and Shoeib, 2015
Dust	Canada, Vancouver	2007-2008	116	Residential houses	7.5 (<0.70-170) 99%	11 (<0.70-170) 99%		Whole vacuum cleaner bag	Shoeib et al., 2012
Dust	USA, Massachusetts	2002-2003	38	Residential houses	3.16 (max 43.1) 89%	9.60 (max 68.4), 100%		Whole vacuum cleaner bag	Johnson et al., 2013
Dust	Australia (A), United Kingdom *of Great Britain and Northern Ireland* (UK), Canada (CA), Sweden (S), China (CH)	A: 2014, UK: 2008-2009, CA: 2014, S: 2014, CH: 2012	A=4, UK=4, CA=6, S= 5, CH=5	A: Office, UK: house bedroom, CA, S, CH: office	0.04 (0.018-0.19) 100%	0.04 (0.013-0.15) 100%	0.079, (0.032-0.31)		Wong et al., 2017
Dust	USA	2015	12	Student campus, common area. Furniture flammability standard TB133			340, (max 2800), 100%	Campus purchased institutional furniture to meet California's TB133 (which requires furniture to withstand a much larger and longer test flame than TB117)	Dodson et al., 2017
Dust	USA	2015	42	Student campus, dormitory. Furniture			140, (max	Campus purchased institutional	Dodson et al., 2017

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Matrix	Country/ Region/Area	Year	N	Study site Type of location	Mean (range) in ng/g, *air concentrations in pg/m3* detection frequency %			Comment	References
					Syn-DP	*Anti*-DP	Mean ΣDP		
				flammability standard TB133			1900), 100%	furniture to meet California's TB133 (which requires furniture to withstand a much larger and longer test flame than TB117)	
Dust	USA	2015	15	Student campus common area. Furniture flammability standard TB117			15, (max 38), 100%	Campus purchased institutional furniture to meet California's TB117 (The other standard, TB133 requires furniture to withstand a much larger and longer test flame than TB117)	Dodson et al., 2017
Dust	USA	2015	26	Student campus, dormitory. Furniture flammability standard TB117			19, (max 130), 100%	Campus purchased institutional furniture to meet California's TB117 (The other standard, TB133 requires furniture to withstand a much larger and longer test flame than TB117)	Dodson et al., 2017
Dust	USA	2010	19 air-planes, 40 samples	Airplane	110 (40-9500) 100%	330 (92-4200) 100%		Carpet dust. Airplanes represented a wide range of manufacturing dates (1986 – 2008) from five manufacturers (Boeing, Airbus, Canadair Regional, McDonnell Douglas and Embraer).	Allen et al., 2013
Dust	USA	2010	19 airplanes,	Airplane	160 (34-2200) 100%	300 (31-9600) 100%		Air return grills. Airplanes represented a wide range of	Allen et al., 2013

Matrix	Country/ Region/Area	Year	N	Study site Type of location	Mean (range) in ng/g, *air concentrations in pg/m3* detection frequency %			Comment	References
					Syn-DP	*Anti*-DP	Mean ΣDP		
			40 samples					manufacturing dates (1986 – 2008) from five manufacturers (Boeing, Airbus, Canadair Regional, McDonnell Douglas and Embraer).	
Dust	China, Beijing	2012	3	Hotels	-	-	124,000	Highest level of DP in small particles, 7-20 µm	Cao et al., 2014
Dust	China, Beijing	2012	2	Kindergarten	-	-	231	Highest level of DP in small particles, 7-20 µm	Cao et al., 2014
Dust	China, Beijing	2012	2	Kindergarten	-	-	1,350	12± 10 µm, dust particle fraction	Cao et al., 2014
Dust	China, Beijing	2012	2	Kindergarten	-	-	1,530	7± 7 µm, dust particle fraction	Cao et al., 2014
Dust	China, Beijing	2012	40	Dormitories	-	-	14,200	Carpeted, Highest level of DP in small particles, 7-20 µm	Cao et al., 2014
Dust,	China, Dongguan	2013	102	Indoor	-	-	68.5 (nd-622)	Highest level of DP in small particles, 7-20 µm	Chen et al., 2014
Dust	China, Dongguan	2013	20	outdoor	-	-	22.9, (1.44-93.1)		Chen et al., 2014
Dust	China, Guangzhou		51	House dust	5.3 (<LOD-216) 78%	19.4 (<LOD-834) 98%	24.5, (nd-1050)	Median. DBDPE dominated	Tang et al., 2019
Dust	China, Guangzhou		31	Children's hand wipe	0.02 (nd-0.2) 68%	0.1 (nd-1.4) 97%	0.1, (nd-15)	Median. DBDPE, DE209 and BEH-TEBP dominated	Tang et al., 2019

Matrix	Country/ Region/Area	Year	N	Study site Type of location	Mean (range) in ng/g, *air concentrations in pg/m3* detection frequency %			Comment	References
					Syn-DP	*Anti*-DP	Mean ΣDP		
Dust	China, Guangzhou		51	Adults' hand wipe	0.04 (nd-1.5) 76%	0.14 (nd-5.3) 94%	0.2, (nd-5.6)	Median. DBDPE, BDE209 and BEH-TEBP dominated	Tang et al., 2019

DBDPE= decabromodiphenylethane

BDE209= decabromodiphenylether

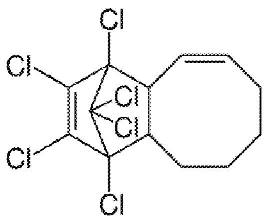
BEH-TEBP= bis(2-ethylhexyl)- 3,4,5,6-tetrabromo-phthalate

Table 13. Median concentration (ng/g lipid) of Dechlorane Plus and its isomers and de-chlorinated DP in human samples

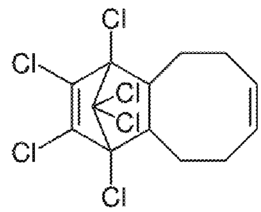
Country/Region/Area	Matrix	Year	*n*	Detection frequency %, *syn; anti*-DP	*Syn*-DP	*Anti*-DP	ΣDP median	Σ DP range	*Anti*-Cl_{11}-DP	*f-anti*	Reference
Norway	Serum	2012	48	78; 89	0.45	0.85	1.3		-	0.67	Cequier et al., 2015
Norway	Serum	2013	61	3; 3	<0.80	<2.1					Tay et al., 2017
Germany, Red Cross donors	Serum	2013-14	42	93; 79	0.77	1.23			-	0.57	Fromme et al., 2015
France, people living in area of a municipal solid waste incinerator	Serum	2003-05	48	75; 94	0.22	0.89	1.20		-	0.75	Brasseur et al., 2014
Canada, maternal serum	Serum	2007-09	102	77; 87	0.49	1.9	2.37			0.81	Zhou et al., 2014
Republic of Korea	Serum	2013	61		0.21	0.52	0.75			0.74	Kim et al., 2016
China, residents of Shandong Province	Serum	2014	490 in 20 pooled samples		-	-	2.1 (mean)			0.62-0.82	Ma et al., 2017
China, residents of Shandong Province	Serum	2015	452 in 20 pooled samples		-	-	3.1 (mean)			0.62-0.82	Ma et al., 2017
China, surplus serum from routine pathology testing, residents of Laizhou Bay, within 10 km from previous production site male	Serum	2011	146 in 5 pooled		3.1(mean)	1.1 (mean)	4.3 (mean)				He et al., 2013; Wang et al., 2014;
China, surplus serum from routine pathology testing residents of Laizhou Bay, within 10 km from previous production site female	Serum	2011	141 in 5 pooled		2.0(mean)	0.95(mean)	2.9 (mean)				Wang et al., 2014; He et al., 2013
China, e-waste dismantling region	Serum	2005	20		17.10	21.20	42.6			0.53	Ren et al., 2009; 2011
China, fishing industry region	Serum	2005	20		5.10	8.60	13.7			0.64	Ren et al., 2009; 2011
China	Serum	2011	10		2.50	1.00	3.6			0.35	He et al., 2013
China, > 20 yrs residential time in e-waste recycling region	Serum	2010-11	33		2.75	5.95	8.64			0.70	Ben et al., 2013
China, < 3 yrs residential time in e-waste recycling region	Serum	2010-11	16		0.95	2.71	4.09			0.75	Ben et al., 2013

China, > 20 yrs residential time in e-waste recycling region	Maternal serum	2010-11	48		2.40	6.16	8.43	1.28-900	0.371	0.72	Ben et al., 2014
China, < 3 yrs residential time in e-waste recycling region	Maternal serum	2010-11	20		0.82	2.83	3.55	1.69-11.6	0.155	0.75	Ben et al., 2014
China, occupational exposure DP plant	Blood	2011	23		386	471	857	89.8-2958		0.54	Zhang et al., 2013
China, workers without direct DP exposure	Blood	2011	12		143	207	350			0.60	Zhang et al., 2013
China, residents near DP manufacturing plant	Blood	2011	12		106	207	243			0.61	Zhang et al., 2013
China, > 20 yrs residential time in e-waste recycling region	Cord blood	2010-11	48		0.959	1.89	2.82	0.680-89.7		0.67	Ben et al., 2014
China, < 3 yrs residential time in e-waste recycling region	Cord blood	2010-11	20		0.660	1.40	1.82	0.450-27.2		0.67	Ben et al., 2014
China, > 20 yrs residential time in e-waste recycling region	Placenta tissue	2010-11	48		0.728	2.75	3.21	0.92-197	0.0767	0.74	Ben et al., 2014
China, < 3 yrs residential time in e-waste recycling region	Placenta tissue	2010-11	20		0.32	0.90	1.09	0.459-2.86		0.75	Ben et al., 2014
Canada	Milk	2004, 2009	87	74; 85	0.27	0.71	0.98			0.67	Siddique et al., 2012
Canada	Milk	2007-09	105	40; 50	nd	0.02	0.02			0.80	Zhou et al., 2014
China, > 20 yrs residential time in e-waste recycling region	Milk	2010-11	33		1.33	3.32	4.46			0.71	Ben et al., 2013
China, < 3 yrs residential time in e-waste recycling region	Milk	2010-11	16		0.50	1.58	2.19			0.76	Ben et al., 2013
China, occupational exposure DP plant	Hair	2011	23					4.08-2159			Zhang et al., 2013

Figure 1. Two different isomers of Dechlorane Plus monoadduct (DPMA) have been detected in the environment

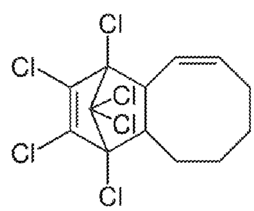
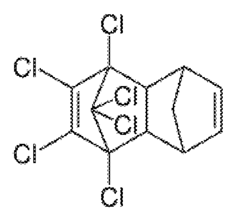
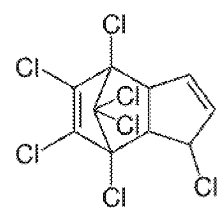


1,5-DPMA



1,3-DPMA

Table 14. Dechlorane Plus monoadduct and possible grouping approach

Properties	DPMA	Aldrin	Heptachlor
Structure			
Molecular diameter Å	8.7	8.7	8.6
Van der Waals's volume, Å	231	210	202
MW	380.96	364.92	373.32
Water solubility, 25°C	0.003 mg/L	0.017 mg/L	0.18 mg/L
Log K_{ow}	7.2 (predicted)	6.5 (measured)	5.5 - 6.1 (measured)

Prediction OECD QSAR Toolbox v2.1

Information from ECHA, 2017c.

Both Aldrin and heptachlor are listed in Stockholm Convention.

"WHO (1989) reports that aldrin is rapidly converted to dieldrin by epoxidation of the double bond in the environment, and that a large number of microorganisms are capable of promoting epoxidation. Aldrin and dieldrin are highly toxic substances, and dieldrin is much more resistant to biodegradation (WHO, 1989). Their historical use as neurotoxic insecticides means that they target the central nervous system, but a variety of other effects have been observed in mammals and birds, including on the immune system and liver (WHO, 1989). The mode of action could involve the alkyl bridge (e.g. via hydroxylation), so this does not automatically mean that DPMA would cause effects of the same type or at similar concentrations.

Heptachlor is also highly toxic. EFSA (2007) highlights that the two main transformation products of heptachlor – heptachlor epoxide and photoheptachlor – are persistent, lipophilic and toxic" ECHA, 2017c.

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